Cochran (J.)

THE

GENERAL PRINCIPLES OF ORGANIZATION,

AND THE

EVOLUTION OF ORGANIC FORMS.

FIRST ANNUAL ADDRESS

BEFORE THE ALUMNI SOCIETY OF THE MEDICAL DEPARTMENT OF THE UNIVERSITY OF NASHVILLE. DELIVERED IN THE HALL OF THE MEDICAL COLLEGE, FEBRUARY 23, 1870.

BY JEROME COCHRAN, M.D.,
PROFESSOR OF CHEMISTRY IN THE MEDICAL COLLEGE OF ALABAMA.

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ANNUAL ADDRESS.

Gentlemen of the Alumni Society of the Medical Department of the University of Nashville:

I COME before you with feelings of more than ordinary pleasure—pleasure partly of purely selfish and personal concernment, because of the honor you have done me in selecting me to deliver your first Annual Address, and partly of quite general and public import, because I see in the organization of our Society the rise of a beneficent power in the land whose influence may be made to extend over large realms, both of space and of time, and to descend in blessings on the heads of thousands. I come before you also with a sense of more than ordinary responsibility. I see here the officers and members of our Society of Alumni, gathered together from all parts of the Mississippi Valley, the representatives of the medical profession of a region of country so vast in its expanse of square miles, and so affluent of plenty in the fertility of its soils and the variety of its climates and productions, that it might furnish comfortable sustenance to one-half of the population of the world—a region whose possibilities of temporal prosperity and material grandeur defy all the vocabularies of earthly lan-

guages to image or to name them. I see here a congregation of intelligent men and women of widely extended social, political, and religious influence—men whose valor shall be felt on many a field where right and wrong engage in desperate battle, whose wise counsels shall command the applause of listening senates, and give shape to the destinies of nations; and women redolent of all the graces and dignities of home, sweet home, the true woman's true kingdom, over which she is sovereign by divine right—women content to remain what God, in his inscrutable wisdom, has made them, knowing full well that there are no more honorable titles known among men than those of wife and mother. And here, too, along with this congregation of fair women and brave men, I see a shadowy congregation of memories and hopes whose power is greatest in the hearts of greatest men. For out of the dim past come the memories of the glories and humiliations which we have inherited from our ancestors; and out of the dim future come the destinies that await our children, and our children's children, for generations without name or number:

> Hopes, and fears that kindle hope,
> An undistinguishable throng.

In the presence of such an audience, and under the influence of circumstances so full of suggestion and emotion, I cannot venture to indulge in empty commonplaces and idle compliments. As the great apostle felt resting upon him the weight of an ineffable obligation to preach the gospel of Christ, and I hope I may say it without irreverence or presumption, so I also feel it incumbent upon me to bear testi-

mony, in my humble way, to such principles of everlasting truth as God has enabled me to see with unclouded vision, and to embrace with abounding faith, with the hope that my words, like bread cast upon the waters, may be gathered after many days, or, like the seed of the sower which fell upon good ground, may spring up and bear fruit, some thirty, some sixty, and some an hundred-fold.

Estimating at so high a rate the privileges and the responsibilities of the office to which you have called me, I need not tell you that the selection of a subject for discussion before you has caused me much anxious thought. I might attempt to entertain you by a sketch of the history of the growth and development of the science and art of Medicine, commencing with the fabulous centuries that lie beyond Hippocrates, and passing with rapid steps through all the historic periods that lie between the immortal Greek and the effulgent blaze of civilization in the middle of the nineteenth century. But this theme, although a grand one, has been made use of so often on occasions like this, that it must be familiar in all its details to all of you. Or, I might give you some account of the organization and subsequent progress of the Medical Department of the University of Nashville, the cherished *Alma Mater* in whose honor we have assembled—might tell you how, under the wise management of her founders, and without adventitious aid from public or from private munificence, she has grown, in less than twenty years, to be the full equal, in every element of power and prosperity, of any institution of the kind, old or new, in all the wide territories of this American Continent. No subject could be thought of more appropriate to the oc-

casion, or more agreeable to my feelings and to yours. But the story has been lately told by an honored member of the Faculty of Medicine, in such eloquent and stirring fashion as I can never hope to emulate; so that this also is ground upon which I cannot venture to intrude. Only as the representative, and in the name of her twelve hundred sons, I may be allowed to say, that the filial reverence and gratitude which we feel toward her shall never grow cold in our hearts. Our obligations to her are such as can never be repaid by money, or by money's worth; but as she has loved and honored us, so shall we love and honor her, remembering her always to serve her, and coupling her name always with prayers and with benedictions.

Instead, then, of addressing you on one of these familiar themes, or on some other familiar topic of medical history, or of medical ethics, or of medical politics, or of medical education, I have thought it better to take advantage of the fact that our Society is but newly organized, or indeed hardly organized at all, to call your attention to a brief discussion of some of those elementary principles, universal and immutable, upon which all organization must proceed; the principles of organization which Almighty God has followed in the construction of all that he has made, whether little or great; and which we also must of necessity follow, according to our human capacity and fashion, in all the works of our finite hands, whether accomplished under the influence of blind instinct or of intelligent reason. And as the study of no organism is complete until we have some knowledge of its environment—that is to say, of its surroundings and of the coincident influences which modify its activity,

whether favorably or adversely—it becomes necessary also for us to take a glance at the characteristics and peculiarities of the age in which we live—to make some summary estimate of prevalent philosophical doctrines, and of their influence in the physical, moral, intellectual, social, political, and religious development and growth of communities and individuals, states, churches, societies, and families.

Of course I shall be able to do this only in the most abstract and general way, and so shall be liable to frequent misconception. I therefore beg of all of you, in advance, that you will bear patiently with the dogmatic statement of the most important propositions; that you will cover over with the soft mantle of charity—that charity which envieth not, and which is not puffed up—whatever I may say that may seem impossible, extravagant, or absurd; and that you will do me the favor to believe that the philosophical opinions which I shall assert, even those which are most in conflict with prevalent philosophical doctrines, have still, in the immutable nature of things, some solid foundations to rest upon. It is no part of my purpose to attempt to prove any thing, in the ordinary sense of the word proof, but simply to develop some germs of truth, to suggest some trains of thought, to open, if I can, the eyes of your understandings, so that you may look out and see for yourselves, sometimes perhaps as through a glass darkly, and sometimes also, I hope, face to face, those immutable and everlasting truths which the infinite Father has made to shine like suns in the firmament forever for the enlightenment of all his children, and especially of them that love him. *Especially of them that love him!* Words memorable forevermore. For the

heat of the sun is no less needed than his light for the development of animal and vegetal life in earthly faunas and floras; and the warm heart, overflowing with the love which thinketh no evil, is quite as necessary as the clear head, for the apprehension and comprehension of the highest truth.

The problem of the universe is the problem of organization and development. In the last analysis of things, organization and development are the miraculous words which furnish explanation of all the mysteries of Nature, making her crooked paths straight and all her hidden things plain. Nature, through all her kingdoms, principalities, and powers, is *one*, and not *many;* or rather, she is both *one* and *many*. Hence, we find that, in all organisms of every possible kind and degree, in plants, and animals, and states, and churches, the principles of organization and the processes of development are always and everywhere one and the same. Hence, also, it follows that the explanation of any single organism, even the simplest and easiest of all, is the explanation of all organisms; is the adequate explanation of universal nature; is, indeed, in simplest truth reverently spoken, the explanation of God himself, so far as he can be made comprehensible to finite and human intelligences. It is not difficult to understand *how*, or at any rate *why*, this is so. For all things have one common origin, God being the infinite Author of all. And truth is always the same, without variation or the shadow of turning, because God cannot change. And God passes entire into every one of his works, because every creature must partake of the nature of its creator, and God cannot be divided.

Hegel's paradoxical definition of philosophy as the Science of the Identity of Identity and Non-identity, notwithstanding the apparent contradiction which it involves, gives forcible expression to a great philosophic truth—the truth, namely, of the essential and immutable *unity* which sustains and pervades all the infinite *diversity* of thoughts and things—a marvelous unity in which we see in mystical and ecstatic vision

> All things with each other blending,
> Each to all its being lending,
> All on each in turn depending,
> While everywhere diffused is harmony unending.

In any thing like a complete and systematic discussion of the principles and processes of organization, the subject is seen to divide itself into two great sections—the one static, the other dynamic. The first of these sections—the static—is conversant about the materials of which organisms are composed, and the forces with which they are endowed. It includes such questions as the relations between organic and inorganic nature—the interconnections and dependences which obtain between them; and the relations between organization and life, whether the one underlies and sustains the other, or whether they both rest side by side in inseparable alliance, on a common foundation. The second of these sections—the dynamic—is conversant with the laws of evolution and the process of the development of organisms. It includes the discussion of the relations between plants and animals, and between the several classes, orders, genera, and species of each; whether all the tribes and families of earth's faunas and floras have one common origin,

passing by gradual development from one type to another, under the influence of incident forces and the law of natural selection, or whether each is the result of separate miraculous creation; and whether social, political, and ecclesiastical organisms are essentially of the same nature, and obedient to the same laws as organisms belonging to the vegetal and animal kingdoms; whether, indeed,

> All things
> Are of one pattern made;

whether

> Bird, beast, and flower,
> Song, picture, form, space, thought, and character,
> Deceive us, seeming to be many things,
> And are but one;

or whether the grand philosophical and practical conception of the unity of nature is, after all, only a vain delusion or an empty dream.

Organisms exist only for the manifestation of force, for the generation of motion; and this force, or motion, which is thus found always in alliance with organization, is what we call life. When it occurs in plants, it is vegetal life; in animals, animal life; in societies, social life; in states, political life; in churches, ecclesiastical life. Exactly what relation exists between organization and life is a problem not easy of solution. It is not even easy, or perhaps possible at all, to determine which is first in the order of causes. They are always found together, in inseparable copartnership. Without organization, we have no life; and without life, we have no organization. So far as scientific observation extends, they appear simultaneously in each new

individual, neither seeming to precede nor to succeed the other, but both exhibiting the character of ultimate biological facts.

Through considerations of this sort, biology is placed in affiliation with the other natural sciences, more immediately with chemistry and physics; the study of man becomes a part of the general study of nature; and it becomes easy to determine its place in the scientific hierarchy. In ultimate scientific analysis, we find everywhere two things remaining, namely, matter, and the forces of matter, or, in shortest words, matter and motion; and these two are always found in inseparable union. "Give me matter and motion," said Descartes, "and I will construct the universe." And this is no empty *bravura* of ambitious rhetoric, but an authentic deliverance of positive philosophy. Hence, at the foundations of our physical science, we have two laws, namely, the law of the indestructibility of matter, and the law of the indestructibility of motion.

The doctrine of the indestructibility of matter is of great antiquity. It was held by Democritus and Epicurus, and is expounded, with his usual subtlety of thought and splendor of diction, by Lucretius in his immortal poem. But, in the shape in which we now have it, it was first formularized into a law of science during the latter part of the eighteenth century, when the discovery of gases and the increasing resources of chemical analysis enabled physicists to substitute for creation and destruction the positive conceptions of composition and decomposition. From this law it necessarily results that the quantity of matter in the universe remains always the same, suffering neither augmentation

nor diminution. No new atom is at any time called into existence. No old atom, having performed its allotted mission in the world, passes at any time through the valley of the shadow of death, to be numbered with the things that were.

> As the great world spins forever down the ringing grooves of change,

there is transformation and metamorphosis without end, but no annihilation. And marvelous beyond the imagination of man to conceive, are the transformations and metamorphoses of universal matter; one while it may be diffused in nebulous fire-mists through the abysses of space; another, while it may be gathered into constellations and galaxies of stars. During one millennium it may utter its aspirations in trees and flowers; and during the next, it may traverse continents and seas in the bodies of carnivorous mammals. An animated atom whirling through the proud heart of a Russian Czar on Monday morning, may be masticated in a carrot by the meanest of his vassals on Saturday night.

> Immortal Cesar, dead and turned to clay,
> May stop a hole to keep the wind away.

The law of the indestructibility of force is of more recent origin. The researches of Davy, Arago, Becquerel, Faraday, and others, served to establish it on a firm basis; and the principle is now accepted without question by all scientific authorities. It is easy indeed to show, by direct experiment, that the transformations and metamorphoses of motion are quite as numerous, quite as important in the economy of the universe, and quite as wonderful in the

contemplation of human reason, as those of matter; that heat, light, electricity, magnetism, chemical affinity, and the whole catalogue of imponderable agents, are mutually convertible each one into all the rest; in other words, that they are all but the Protean metamorpheses of motion. It is also easy to show that the three laws of motion—namely, Kepler's law of inertia, Galileo's law of the coëxistence and composition of motions, and Newton's law of the equality of action and reaction—admit of application to all the phenomena of force, whether in the inorganic or the organic world.

Starting from principles like these, against which it is impossible to urge any valid objection, the tendency of contemporary science is undoubtedly to reduce all the phenomena of life, and of intelligence, and of whatever in man is higher than these, if any such thing there be, into mere functional activities of organization, into mere modes of motion; and to make the differences between organic and inorganic nature, striking as they are in multifarious details, altogether formal and gradational, the same immutable laws and substances obtaining in both. So far as any hypothetical vital principle is concerned, we seem to have ample warrant for the assertion that, as all the material elements of living organisms are derived from inorganic nature, so also the so-called vital forces of plants and animals are not radically different from the physical and chemical forces of inorganic matter, but are indeed the same identical forces operating through the medium of more complex conditions; that, as the same matter out of which stars and nebulæ are made, is sufficient for the composition of all vegetal and

animal tissues and organs, so the same august forces which wheel the planets around the suns, and the suns around far-off unimaginable centers, and which preside over all physical and chemical phenomena, are also regnant in all the kingdoms and provinces of organic nature—in other words, that gravitation, and cohesion, and chemical affinity, and the vital force, are all, in their last analysis, identical.

Let us take two or three concrete examples in illustration of these two fundamental laws:

You all know, in a general way, how plants grow by the gradual assimilation of those material substances which constitute their natural food. These material substances, leaving out certain metallic salts, and certain organic matters which are derived in fractional quantities from the soils in which the plants grow, are chiefly the familiar chemical elements, carbon and hydrogen. When some vegetal seed is planted in the ground, as, for instance, a grain of corn or of wheat, under the influence of heat and moisture it swells up, and presently the germ begins to grow. In this first stage of growth the young plant, just like any other young creature, needs food easy of assimilation and specially adapted to its feeble condition. Nature, always beneficent and wise, has not neglected to make the necessary provision. The seed is composed of two principal parts, the germ which is to be developed into the future plant—rose-bush, corn-stalk, or oak-tree—around which is stored up in small quantities a substance known as gluten, and a considerable amount of another substance familiar to all of us under the name of starch. This starch is stored up in the seed for the nourishment of the young plant. And here is one of

the most curious parts of the matter. The young plant is not able to eat starch. Its dainty appetite demands sugar, and sugar it must have, or perish. Why, then, did not the mother-plant store up a sufficient supply of sugar for the nourishment of its young? For the very sufficient reason that the sugar would be dissolved by the moisture of the soil and washed away, so that it would not be on hand when wanted. So the mother-plant, wise in her day and generation, taking advantage of the fact that starch is converted into sugar by the action of diastase, which is derived from gluten, accumulates a supply of starch, and provides, in immediate contact with the germ, a little gluten to accomplish the wonderful transformation of starch into sugar. The seed, thus prepared, is buried in the damp soil. The vivifying influence of the sun comes down through a hundred millions of miles of space. Under the joint influence of the heat of the sun and the moisture of the earth, the gluten becomes diastase. Under the influence of the diastase the starch becomes sugar. And the greedy little plant eats up the sugar, just as any human child might do, and grows continually larger and stronger. The stem shoots up through the soil into the soft air which envelops the earth like a mantle; and the roots shoot downward, and become mouths, and eat up whatever food the soil contains. Now, the sugar, which constitutes the principal food of the young plant, is composed of the three chemical elements—carbon, hydrogen, and oxygen—and some very curious laws regulate the proportions of these elements which enter into the compound. These we cannot stop to explain; only I would have you to remember that the hydrogen and oxygen

occur in precisely the same proportions in which they are found in water. The sugar in solution enters the circulating fluid—the sap, the white blood of the plant—and is decomposed into its constituent elements, and out of its carbon and hydrogen the solid tissues of the plant are constructed. The age of infancy being past, and the maternal store of starch exhausted, the plant derives its subsequent food chiefly from the watery vapor and the gaseous carbonic acid diffused through the air. But this power of appropriation, with which the plant is endowed, can only be exerted under certain conditions. The heat and the light of the sun are indispensable factors in the process. The thermal and luminous energy of the sun being added to the vital energy of the plant, the appropriation goes on indefinitely. The carbonic acid is decomposed, and gives its carbon to the growing plant and its oxygen to the circumambient air. In like manner the water is decomposed, and gives to the growing plant its hydrogen, while its oxygen is also added to the atmosphere. Out of the carbon and hydrogen obtained in this way, the solid woody tissues of all vegetal organisms are built up. But observe, they are built up only under the influence of the thermal and luminous energy of the sun. Now, what becomes of this thermal and luminous energy of the sun? Do the calorific and luminous rays, after temporary dalliance with their floral favorites, pass on their way rejoicing to minister to the wants of other organisms? Or, satiated with pleasure, or exhausted with labor, do they sink into the cold arms of death, to be heard of no more forever? Not so.

We have seen how the ponderable material elements,

carbon and hydrogen, are stored up in the solid structures of the plant. The same thing precisely takes place with the imponderable immaterial forces concerned in the processes of vegetal growth. The heat and the light are also stored up along with the carbon and the hydrogen, and so may lie dormant for indefinite centuries—dormant, but not lost any more than the carbon and hydrogen are lost. When the solid tissues of the plant are destroyed, whether by some gradual process of decay, or by some rapid process of fiery combustion, the carbon enters again into combination with oxygen to form the same carbonic acid whence it was originally obtained; and the hydrogen enters again into combination with oxygen, reproducing the original water from which it was drawn. At the same time, the imprisoned light and the imprisoned heat are set free again from the material shackles with which they were bound, and commence another career of beneficent activity.

We have all read, in the veracious history which Mr. Lemuel Gulliver gives us of his travels into strange countries, how on one occasion he found the wise men of Laputa engaged in extracting sunbeams out of cucumbers and carefully storing them away in hermetically sealed bottles, to be let loose when occasion required, to warm the air of inclement winters. I suppose most of you have laughed at these Laputan sages, as men engaged in most whimsical and unprofitable labor; but do you not see what an admirable defense they could make with the help of modern science? Nobody can question the fact that the sunbeams are imprisoned in the cucumbers. Nobody can doubt the ability of science to set them free. And there is nothing in the

nature of things to prevent them from being bottled up for future use.

For the production of heat and light, in most of our cities, we make use of coal and coal-gas. Now, you know that coal is only a transformation of the woody portions of ancient forests, under certain conditions of heat and pressure. These ancient forests, composed of the *sigillaria* and the *lepidodendron*, and other tree-like ferns,

> With fruits and flowers
> Resembling nothing that is ours,

must have covered the earth in luxuriant profusion before it became fitted for human habitation, and under climatic and atmospheric influences very different from those which obtain now in countries where the coal measures are found, when the whole year round was a continuous summer of tropical fervor, and the air was heavy with carbonic acid. Be this as it may, however, we know that the same laws of vegetal growth which prevail now presided also over the strange forests of those remote geological times; that then, as now, the trunks of the trees were built up of carbon and hydrogen derived from atmospheric carbonic acid gas and atmospheric watery vapor; that then, as now, the thermal and luminous influence of the sun passed into the substance of the trees in the process of development; and that both the ponderable material constituents of the coal and its imponderable immaterial forces have lain buried together in the earth for shadowy milleniums which no man can number for multitude. We burn this coal in our grates, and it throws out abundant heat to make our houses comfortable

in the cold winter weather; and after destructive distillation, we burn the gaseous constituents of this same coal in our gas-burners, and it showers its luminous rays about us until the darkness

> Folds its tents like the Arabs,
> And as silently steals away,

and the night is made brilliant and beautiful like the day. Whence have we all this heat and light by means of which such miracles are wrought? It is the same heat and light which came down out of heaven so many, many centuries of centuries ago, when the great fossil ferns multiplied their generations under the sun. Is it not wonderful, more wonderful than any tale of Eastern fable? But the end is not yet. We burn a little of this coal under a boiler containing water, which is attached to a mechanical contrivance called a steam-engine, and see what follows! The first product of the combustion is our now familiar acquaintance, heat. This heat passes into the water in the boiler, and drives its particles asunder so that they occupy a much larger space than before, but now in the form of steam. In this process the heat is lost *as heat*. It has passed through another metamorphosis, and what was heat has become motion. This motion passes on to the engine and becomes subservient to human uses just like the heat out of which it was generated. By means of this motion, long trains of cars are drawn over our railroads, steamboats traverse our rivers, ships cross the great ocean, and the looms and spindles of our manufacturing Lowells and Manchesters convert cotton, and linen, and wool into fabrics wherewithal we are clothed

more magnificently than Solomon in all his glory. And all these wonders are wrought through the agency of heat transformed into motion.

Let us look now at another phase of the problem, and one not less affluent of suggestion. Just as the woody parts of the plant are built up under the influence of the heat and light of the sun, so other parts of the plant are also built up on substantially the same plan—such as green leaves, and pleasant fruit, and the grains that are used for bread; and all these become the food of animals and of men. From vegetal fibers and tissues they are transformed into animal fibers and tissues; and all these vegetal productions which pass thus into the bodies of animals, carry with them not only the material substances entering into their composition, but they carry with them also the dynamic energies, the imponderable forces, which they have received from the sun. In the animal organism these forces are subjected to the action of new agencies, and are transformed into new functions; so that what came down out of the sun as heat, may be introduced into the animal organism as chemical affinity, and, suffering other changes there, may manifest itself in some vital act—may reäppear as motion. Shall we say also as thought? Shall we say also as feeling? Shall we say also as volition? As yet our demonstrations do not reach so far; but it is to this conclusion that all our physical philosophy seems to be tending. Indeed, I do not hesitate to say that, on the principles of purely physical science, this is a conclusion which no legerdemain of logic will enable us to avoid.

The consequences of this course of induction, when ap-

plied to the phenomena of intelligence and volition, are, I know, somewhat more than startling. "Wonder," says Aristotle, "is the first cause of philosophy;" but in the discovery that existence is but mechanism, the consummation of science would be the extinction of the very interest from which it sprang. "Even the gorgeous majesty of the heavens," says a religious philosopher, (Jacobi,) "the object of a kneeling adoration to an infant world, subdues no more the mind of him who comprehends the one mechanical law by which the planetary systems move, maintain their motion, and even originally form themselves. He no longer wonders at the object, infinite as it always is, but at the human intellect alone, which, in Copernicus, Kepler, Gassendi, Newton, La Place, was able to transcend the object, by science to terminate the miracle, to reave the heaven of its divinities, and to exorcise the universe. But even this, the only admiration of which our intelligent faculties are now capable, would vanish were a future Hartly, Darwin, Condillac, or Bonnet to succeed in displaying to us a mechanical system of the human mind, as comprehensive, intelligible, and satisfactory as the Newtonian mechanism of the heavens." "To this testimony," says Sir William Hamilton, "I may add, that should physiology ever succeed in reducing the facts of intelligence to phenomena of matter, philosophy would be subverted in the subversion of its three great objects—God, free-will, immortality. True wisdom would then consist, not in speculation, but in repressing thought during our brief transit from nothingness to nothingness. For why? Philosophy would have become a meditation, not merely of death, but of annihilation; the

precept, *Know thyself*, would be replaced by the terrific oracle to Œdipus—

'Mayst thou ne'er know the truth of what thou art!'

and the final recompense of our scientific curiosity would be wailing deeper than Cassandra's for the ignorance that saved us from despair."

But, without pausing now to seek explanation or reconciliation for this conflict between the physical and the metaphysical philosophies, which in the last analysis will be found to be identical with the immemorial feud between science and religion, between faith and reason, never doubting, however, that reconciliation is to be found if properly sought for, let us approach the second division of our subject—namely, the dynamics of organization. Here there are two leading questions which will engage our attention:

First, the question of the origin of life and the evolution of organic forms.

Secondly, the question of the general principles of organization and development, together with their application to political, ecclesiastical, and social organisms.

And, first, of the origin of life and the evolution of living organisms: whether every animal and vegetal species, of earth, and sea, and air, is the product of separate miraculous creation; or whether they have all sprung from some few aboriginal forms, and from one another, by gradual process of differentiation under the influence of natural laws, evolution, variation, natural selection, and the like.

Nothing is more natural to the human mind than the conception of creation. No thoughts arise more spontaneously

in the human consciousness than the thoughts of *creator*, of *creative act*, and of *creature*. They shine like suns in all the ancient cosmogonies. They find concrete expression in the first verse of Genesis: "In the beginning God created the heaven and the earth." And the ideal formula of Gioberti, *Ens creat existensias*—being creates existences—which is intended to sum up in one comprehensive canon all the principles of philosophy, just as the law of gravitation includes the whole theory of astronomy, is but a repetition in more abstract language of the grand old Hebrew inspiration. Great interests depend on the logical and philosophical legitimacy and sufficiency of this conception. Every principle of moral obligation, and every theory of religious belief, depends upon it. We owe duties and religious worship to Almighty God only on the presumption that he made us, and that consequently we are soul and body his. If he made us not, we are not his, and he has no right to our obedience, no right to our worship. Notwithstanding the tremendous consequences involved in the decision of this question, the science of the day does not hesitate to characterize the hypothesis of creation as essentially illegitimate and absurd—an hypothesis which finds no external support in the facts and inductions of natural science, and which is also destitute of internal evidence, inasmuch as it cannot be framed into a coherent thought; in briefest words, that it is not only unprovable, but essentially unthinkable.

Without pausing now to discuss at greater length the general doctrine of creation, which, as I have said, we must find means to save, or else give up all systems of religious

belief, and all our aspirations after immortality and the beatific vision, we are obliged to concede that the scientific arguments are very nearly triumphant in refutation of the hypothesis of special creations as explanatory of the origin of species in space and time; and very nearly conclusive, also, of the validity of the counter hypothesis of evolution.

The evolution hypothesis, in bare outline, may be briefly stated, both in its affirmative and negative doctrines, as follows, namely:

Negatives: 1. Species do not arise in nature by special creation out of nothing: no such miraculous origin has ever occurred to human experience, and even its possibility is a matter of gratuitous assumption. 2. Species do not arise in nature by special creation out of dead matter: no such phenomenon was ever seen by anybody; and all the analogies and probabilities of nature are opposed to the presumption of its possibility.

Affirmatives: 1. The lowest and simplest species of living things are evolved out of inorganic matter by some mysterious influence of incident forces, not articulately explicable in the present state of science. 2. These lowest types of living things, by progressive differentiation and evolution, give rise to types continually higher and higher, type rising out of type, during the long lapse of geological and unhistoric millenniums, until their forms and numbers have grown so great as to defy all computation.

It is impossible for me to condense here the arguments from classification, embryology, and morphology, which naturalists adduce in support of these propositions. But

there are two or three incidental questions to which I will call your attention.

The first dream of the advocates of the theory of evolution was to arrange all the innumerable varieties of living organisms in a linear progression of gradually increasing complexity, each individual member of the series standing, in physiological character, as well as in orderly arrangement, intermediate between the members below and above it. But it required only a slight familiarity with the natural history of organic forms to show that a rigorously linear arrangement of this kind is impossible—that evolution, in a word, does not travel on a straight line. It is possible, indeed, to arrange organic beings into a larger or smaller number of great natural classes, each several class having certain leading characters, certain organic homologies in common. And we may accept provisionally, and as sufficient for our present purpose, the simplest of the various possible schemes of classification, namely:

First, the division of all living things into two great kingdoms—the kingdom of plants, and the kingdom of animals.

Secondly, the division of the kingdom of plants into two principal sub-kingdoms: (1) *Cryptogamia*, (2) *Phenogamia*.

Thirdly, the division of the kingdom of animals into four principal sub-kingdoms: (1) *Cœlenterata*, (2) *Articulata*, (3) *Mollusca*, (4) *Vertebrata*.

Now, between the numerous tribes and families of each of these sub-kingdoms, comparative anatomy has been able to trace such homologies and resemblances as are sufficient to establish their organic relationship and community of descent; but it has hitherto been found impossible to bridge

over, by transitional forms, the wide and deep abysses intervening between the several sub-kingdoms themselves so as to unite them all into a single organic whole. All effort, indeed, in this direction has been tacitly abandoned by the recognized leaders of biological speculation. Still it is manifest, if the theory of evolution is to be sustained, that, at some stage of their development, all the classes, orders, genera, and species of all the vegetal and animal kingdoms and sub-kingdoms—all the tribes and families of all the floras and faunas of all earth's teeming continents and seas must run together into one common type, where all differences between them are utterly abolished and destroyed. This common type, by common consent, is the simplest of all organisms. It is the biological unit—the simple cell.

From the simple cell, as a common point of departure, and under the influence of natural forces, somehow and somewhere, all living things proceed. That this progression does not follow a right line, in a regular series of organic forms of gradually increasing complexity, we have already seen. Neither is it an adequate solution of the Sphinx's riddle to suppose, with Huxley and Spencer, and other contemporary naturalists, that the various organic types radiate from a common center, along different lines of development. For, on this presumption, it still remains to bridge over the tremendous chasms which lie between the aboriginal cell, whence the process of evolution began, and those complex and perfect forms which represent the highest development of each several type—to trace, for example, the successive steps by which a unicellular protozoan has been developed into a man.

We are therefore, of necessity, forced to return to the linear theory; and, as the arrangement of natural species in a right line has been found impracticable, we must seek for our diagrammatic ideal such modification of the right line, circular or spiral, or branching, as will harmonize with the ascertained facts of natural science. My own conception is that of an immense tree, with two great trunks growing from the same root, and each throwing out innumerable branches—primary, secondary, ternary, quaternary, etc.—all covered with leaves in inconceivable number. In this typical tree, one of the great trunks would represent the vegetal kingdom, and the other the animal kingdom; the primary branches would represent classes; the secondary branches, orders; the ternary branches, genera; the quaternary branches, species of living creatures, while the leaves might stand for individuals.

This problem of passing, by recognizable homologies, from one type of living creatures to another, which, as I have said, has been tacitly abandoned by all the leaders of biological speculation, as impracticable in the present state of natural science, has been attempted with consummate acuteness, and I think with considerable success, by a learned friend of my own, Judge Johnson, of Mississippi. So much of what I have still to say on the evolution of life and the development of organic forms, as is not the common property of scientists, is drawn from his stores, partly from private letters, and partly from published articles, particularly from an article in the Southern Quarterly Review for October, 1868. To a considerable extent, the very language I make use of in this part of my subject is his.

The evolution of life and the development of organic forms! These terms, and the conceptions which they involve, are all the products of our modern science, which ignores the supernatural altogether, and notably the miraculous intervention of creative power, and seeks the explanation of the universe in the operation of natural laws. You will remember how I showed, in my discussion of organic statics, that all the materials and forces of living organisms can be traced back into the domains of inorganic nature—all the materials with articulate certainty, and all the forces, except perhaps the very highest—as volition and intelligence—with more or less probability. Inorganic bodies are composed chiefly of compounds belonging to the class known in modern nomenclature as crystalloids—a class of comparative chemical and physical stability; while the more complex compounds of organic bodies belong to the class known as colloids—a class of comparative chemical and physical instability. The protoplasm, out of which all vegetal and animal tissues and organs are constructed—the physical basis of life, as Mr. Huxley calls it—is an albuminous colloid; that is to say, a nitrogenous colloid, a substance which we are assured could hardly fail to be abundant on a cooling earth. However this may be, the next step is simple enough. Given the albuminous protoplasm, the nitrogenous colloid, and the production of the cell—the biological unit, the chief factor in all organic development—is no more mysterious than the production of crystals by the aggregation of inorganic molecules. Osmotic action alone would cause the differentiation of adjacent parts by the separation of the binary and ternary compounds within its mass—would extemporize a womb;

that is to say, a cell, with its contents. Once originated, once born into the world, this miraculous cell, this thaumaturgic factor of innumerable organisms, will disappear no more. It is endowed with the power of generating its kind. Oxygen, the true father Saturn, begetting and devouring his children, and begetting by devouring never permits it any more to be idle. It attacks the unstable combinations of the colloid, and renders dynamic the forces before comparatively static, or at rest—unchains, in a word, the giants imprisoned and asleep, and rouses them up to forging the thunderbolts of life. All that is farther necessary, to render life systematic and regular, is to suppose that which it is impossible not to suppose, namely, that some part of the cell-wall may be thinner than the rest, or in some way more accessible to the devouring oxygen eagerly desiring to enter to the rape of the sleeping beauty within. This would give rise to circulation; and this circulation, which is the first manifestation of life, like Descartes's motion, is all that is wanted to account for every thing else—up to man. Well, here we have our primitive cell, keeping up a circulation of matter within its walls, and appropriating nutritive material from its environment, and so growing apace, and shooting forth buds, and dividing itself into new cells *ad infinitum*. These primitive cells, with various slight modifications, constitute the various tribes and families of unicellular creatures. They live in an environment readily supplying them with materials for growth and development—that is to say, with food. If the environment is in motion, they generally become fixed, having no need to go in search of the food which is brought to their very doors. *Per contra*, if the

environment is still, they generally move about in order to find the food they stand in need of. The former is the case, for instance, in *algoid* growths; the latter, with *æthalium*. If the environment is very rich in nutritive material, both the environment and the organism may remain at rest, as in *torula cerivisii*. The cellular organisms just mentiond are readily recognized as growers by influences external. There is no antechamber to the reception-room. It is not divided into "Butt and Ben," like a Saxon cottage; all is out of doors. This type Judge Johnson names *exothen* (ἐξόθεν). It is the common type of all those creatures called plants; it being the cardinal characteristic of plants, that no matter how extensive they may be, or how complex, their living cells are all closed sacks, and live by simple osmosis and direct contact with oxygen. If you will place a patch of *æthalia* under a microscope of from one hundred to five hundred powers, you will find, by watching long enough, that these creatures exhibit two phases of existence—a still phase and a moving phase. During their still condition, which is their period of gestation and fructification, they are not distinguishable from ordinary unicellular plants. But if observed when in motion, they might be mistaken for some species of *infusoria;* at any rate, for some sort of microscopic animals. Nothing seems denied to them that is claimed to belong to animal life—neither motion, volition, nor variability. They glide through the water with ease and grace, (for as they inhabit still pools, they must move about to gather the food upon which they live:) or they stick to some object, and crawl about with *amœba*-like motions. In fact, every thing which is attributed to *amœba*,

they may be seen to do, except one. They never inclose in their mass solid, visible particles of food, but remain during their active condition as completely *exothentic* in their mode of life as during their condition of repose.

How different with *amœba*, a creature not so active as the moving *æthalium*, and hardly distinguishable from the latter in its crawling attitude, and yet living in a totally different manner! Instead of depending for its life entirely on osmotic absorption through its external envelops, when it meets with any nutritious substance, it rolls itself around it, improvises a stomach to engulf it, and so carries it about, subjecting it to a rudimentary process of digestion. Now, in these two microscopic creatures, as simple as can be found, we have illustrations of two widely different plans of life. As we have called the first *exothentic*, we may call the last *endothentic*—that is to say, living at home and within doors. This is the common type of all those creatures called animals. It is here that we find the fundamental distinction and point of separation between the two great kingdoms of organic nature, between plants and animals, or, as we prefer to say, with greater scientific precision, between exothens and endothens; and dividing their tribes and families here in this humble realm of microscopic and unicellular life, the two great types proceed, each according to its own proper plan, through indefinite stages of evolution and development. They multiply their multitudinous generations under the same sun, and under the general influence of the same incident forces, but they approximate no more.

Nevertheless, the principle of life and the organic mechanism is substantially the same in both. We have a cell, or

an aggregation of cells, of sarcode or protoplasm—each cell a sack of nitrogenized colloid inclosing something suspended in a fluid, which fluid has a rhythmic circulation. In both, also, the process of evolution, the process of development, by which they increase in complexity and differentiation of organs and functions, is substantially the same, the process, namely, of *involution;* that is to say, the folding up, or rolling in, of the organism upon itself. For instance, the leaf, or frond, is the common type of every exothen more complex than the simple cell. The frond-like sheet of single cells, which we see, in *ulvaceæ*, folded in upon itself so as to make a double layer of cells, is the type of the next higher form, or *filices*. And this double sheet folded again so as to form four layers, is the type of the phenogamous. This process of duplication and reduplication of sheets of cells is a process of involution. But the involution which constitutes the passage from plants to animals, from exothens to endothens, is an involution of an entirely different character. *It is the doubling in upon itself of the single individual cell.*

In *amœba* this involution is only temporary. But in the various forms of *cœlenterata* the temporary stomach of *amœba* becomes permanent, and the organism assumes the form of a cup, in which the same aperture serves for the ingress of food and the egress of refuse matter—the mouth is also the vent. We have an example of this sort of creature in the hydra. In the next step, in the ascending evolution of endothens, the opposite lips of this mouth come together, and adhere in their central, which are also their least used portions, leaving the two corners open. One of these continues mouth, the other becomes vent, and the

perinæum-like structure which stretches between them is henceforth the ventral aspect, the belly of the animal. Let us understand still more clearly, if we can, the nature of the change which has taken place. A simple unicellular exothen is a closed sack. A simple unicellular endothen is also a closed sack, but an involuted closed sack, a closed sack doubled in upon itself. The original sack has never been ruptured. Nowhere, at no time, for no purpose, is it ever ruptured. From the first simple colloid cells, which floated in the teeming waters of the primitive world, up through all the ranks and files of living things to the complex circulatory system of the highest mammals, there is never any entrance into this sack except by the one invariable process of osmosis. Mr. Huxley says: "Imagine a ball of putty covered over with a layer of India rubber: you can mold the putty into any shape you please, and the India rubber envelop follows it, adapting itself to all its various shapes. Stick your finger down into the ball, molding it into the shape of a cup, and you have the type of *cœlenterata*, the type of the lowest animals. Run your finger entirely through the ball, and you have the intestinal tube of higher animals, of *mollusca* and *vertebrata*." But not so; Mr. Huxley makes an immense mistake. *Per contra*, let your India rubber sack be filled with a living, circulating fluid; then mold it into all these cunning forms, taking care never to rupture the investing membrane, and you have the plan of nature.

Having progressed thus far, we have a unicellular animal, a unicellular endothen, as we have agreed to call it—an endothen of one cavity, of one segment. Now, these mono-

segmentary endothens tend to multiply and compound their segments, just as exothentic creatures multiply and compound their cells; only, instead of laying together cell after cell, they add segment to segment, in one direction, or in many. With a single axis of evolution, we have, in this way, ring after ring, constituting the compound forms known as *articulata*. The first effort of these segmentary endothens is to multiply their segments indefinitely. But Nature, failing in this direction to obtain the increase of force she is in search of, changes her policy, and endeavors, by integration, to concentrate the powers of the articulate type into a few segments. Thus the number of segments is reduced to twenty, the type of insect life; and, the process of reduction still going on, some of these twenty are allowed to encroach upon, and to corrode into atrophy, some others, until finally they are reduced to two. In some of the higher *articulata*, along with the diminution of the number of constituent segments, we observe a tendency of the organism to double down upon itself, as in crabs, and more or less in the whole entomostracous order.

It is here that Judge Johnson makes the passage from the multisegmental *articulata* to the bisegmental *mollusca*. It is true, there are some forms of lowest *radiata* and of lowest *molluscoida*, which look as if the connection were there. And this would be according to the usual analogy, that the connecting links of orders and classes are to be observed in their lowest and fetal forms, and not in their highest and most divergent. But in this case, urges our Mississippi *savan*, the passage from *crustacea* to *mollusca*, through *cirrhipeda* and *entomostraca*, seems so simple that it

is difficult to avoid the belief that this is the actual route along which organic evolution has traveled in its slow and tortuous ascent toward *vertebrata*. In *cypris* we find two dorsal scales developed, so as to form a bivalve crustacean, which is obliged to fold in its head and abdominal parts by twisting over to one side. In *daphnia pulex* and *apis*, the twisting over is permanent, so that the axis of life seems exactly at right angles to the scales, which are now attached to each side, and not making a box for it as in *cypris*. In the *cirrhipeda* we find similar creatures, only much larger, swimming about like ordinary crustaceans, but of the entomostracous type. These, sticking the head presently to a rock or piece of floating timber, lose all traces of that organ, and retain in other parts a half crustacean and half molluscous character, only waiting to have the legs changed into net-like gills to resemble an oyster. These examples render comprehensible the evolution of *mollusca*, by the development of two segments of *articulata*, whether they establish this as the process actually pursued or not. For myself, I must be allowed to say that, while I regard it as incomparably the best attempt that has yet been made to solve the cardinal problem of animal morphology, as indeed the only attempt worthy of any serious consideration, I still hold that the demonstration is incomplete. Nevertheless, I do not doubt that the articulate type is transformed into the molluscous. My criticism simply is that the process of transformation has not been sufficiently explained. But here, as I have said, in this passage of *articulata* into *mollusca*, as an intermediate, or rather as a preparatory, stage in the ascent toward *vertebrata*, is the cardinal

problem of animal morphology. The passage from the unicellular plant to the unicellular animal, by the doubling in of the cell upon itself, is plain enough. The development of various forms of cœlenterate and articulate animals out of the simplest unicellular protozoan is also sufficiently intelligible; since, in all this, there is no change of plan, but simply a multiplication and arrangement of homologous segments. But, in passing from *articulata* to *mollusca*, we find that nature has adopted a new plan. There is evidently another *involution;* not an involution of the individual cell, such as marks the transformation of a plant into an animal, but the folding in upon itself of a complex organism, analogous, perhaps, to that which characterizes the transition of cryptogamia into phenogamia in the vegetal kingdom. And this *involution* is also plainly the last which has as yet been attained in the process of organic evolution. Nature changes her plan no more, but confines her labor to the improvement of this last offspring of her love and wisdom—to the development of this bisegmentary, deutendothentic, molluscous type—a type of two segments with the axis of life lying between them. In this type, therefore, the axis of life occupies a position exactly at right angles to the axis of life in the articulate type, since, in *articulata*, the axis of life passes through the segments as a string might pass through a succession of rings. Between *mollusca* and *vertebrata*, the relationship is analogous to that between *cœlenterata* and *articulata*—a relation of complexity, of adaptation, of special differentiation. The mollusk is, so to speak, the embryo of the vertebrate—the prefiguration and prophecy of man, *Homo bimana sapiens.*

The details of the evolution of complex vertebrate organs out of this molluscous embryo are too voluminous for me to attempt their discussion even in outline. But there is one luminous doctrine which, since it underlies all of our theories of organic evolution, I feel that I ought not to pass over altogether without mention. It is this: Those simple unicellular creatures, in which life first made its appearance on our globe, were composed of two very diverse parts, namely, a part contained, which was fluid, and a part containing, which was solid. In like manner, all living organisms, from the lowest to the highest, are composed also of two parts—of fluids and of solids. The fluids in all are inclosed in a vessel, or a system of vessels, which has no outlet, and are homologous in all with the fluid contents of the original colloid cells. The solids, however arranged into complex tissues and organs, are all derived from the original colloid envelop of the primitive cells. In other words, all the tissues and organs of all organic creatures are of tegumentary origin; so that the bones, muscles, and nerves of all animals, together with all the organs into which they enter as factors, the stomach which digests food, the liver which secretes bile, the heart that beats, the lungs that breathe, the brain that thinks, and the limbs, with all their cunning uses, are all, to speak somewhat paradoxically, evolved out of skin.

We must pass on now to some consideration of the general principles of organization, and their application to social, political, and ecclesiastical organisms.

All development proceeds from the simple to the complex, from the one to the many, from unity the most absolute to multiplicity the most infinite. As organisms rise

higher and higher in the scale of existence they become more and more complex; so that complexity of organization is the exact measure of perfection of organization: the greater the simplicity, the less the perfection; the greater the complexity, the greater the perfection. The typical attribute of inorganic bodies is homogeniousness of structure, in which every particle is like every other particle; that is to say, in which every particle has all the characters of individuality, so that there is no distinction either of tissues or of organs. The lowest plants and animals are manifestly those in which there is least departure from the conditions of inorganic existence; in which, consequently, the differentiation of tissues, and organs, and organic functions, has made smallest advancement; and in which, consequently again, simplicity of organization is at the *maximum*. On the other hand, it is equally manifest that the highest plants and animals are those in which there is most departure from the conditions of inorganic existence; in which, consequently, the differentiation of parts, and the multiplication of tissues, and organs, and organic functions, has made greatest advancement; and in which, consequently again, complexity of organization is at the *maximum*.

The simplest plants, the humble family of *algæ* for example, have neither root, nor stem, nor leaf, nor flower, nor seed. But all these organs, appropriated to the discharge of special functions, enter into the complex organization of those plants which stand highest in the scale of vegetal existence.

The lowest animals, as for example rhizopods and sponges, have no legs, no arms, no heart for the circulation of the blood,

no lungs for respiration of air, no alimentary canal subservient to nutrition, no nerves to thrill with pleasure or shudder with pain, no organs of smell, or of taste, or of hearing, or of sight, no thaumaturgic brain to think, and feel, and build up, along the march of the centuries, philosophies, and governments, and religions—none of those admirable adaptations of differentiated organs to special functions which, in their whole assemblage, make man, the acknowledged lord of creation, the most complex, and at the same time the most perfect, of animal organisms.

This is that wonderful law of evolution which, in its applications to the world's faunas and floras, we have already considered in some detail. We have seen that, in its biologic bearing, it applies as well to human beings as to humbler creatures; and we are now to learn that it is supreme in sociology as well as in biology; that it not only presides over the development of man as an individual animal organism, but that it presides also over those complex social organisms into which human beings enter as constituent atoms, as units of composition, as smallest factors—those organisms, namely, which are known to us as states and churches.

Among nations, those which are most savage and barbarous are also those which exhibit the greatest simplicity of organization, those in which we find the smallest differentiation of social, political, and ecclesiastical institutions. As they advance in intelligence and civilization, so do they also advance, with equal step, in complexity of organization; separating class from class, adding institution to institution, specializing different social, political, and ecclesiastical

organs for the performance of different social, political, and ecclesiastical functions, until a complexity of organization is attained which almost baffles our powers of analysis, as in the Christian civilizations of modern Europe. If you would appreciate the difference, by individual examples, compare civilized England with savage Dahomey; or the Anglo-American civilization, on this continent, with that of its aboriginal inhabitants. Standing in immediate relationship with the train of thought we are now pursuing, there is one consequence of the law of evolution which I desire to bring into greater prominence, namely, this: *That all development takes place under restraint;* that everywhere in nature, every step in advance involves subjection to conditions continually more and more stringent. Your thorough-going savage is the most independent man in the world—the man who enjoys the most unbounded freedom. He provides his own food, makes his own clothes, builds his own house, and fights his own battles; is, in a word, farmer, hunter, soldier, sailor, tailor, carpenter, mason, merchant, and twenty other trades and professions, all in one; and, withal, owes very little subjection to laws of any sort, whether human or divine; it being very nearly true, that he cares for nobody and nobody cares for him. In civilized communities all this is changed. The people are divided into various classes, following various occupations. Thus we have, in most general terms, an agricultural class, and a manufacturing class, and a commercial class, and a professional class; and all these great classes are divided, and sub-divided, and sub-sub-divided into classes smaller and smaller, until their multitude becomes so great that it is almost impossible to number or to

name them. Each of these smaller classes is engaged in a special work of its own, and makes its own special contribution to the general welfare. Each is a special organ of the body politic, charged with the performance of a special function; while the whole organism is the result of the operation of natural laws—evolution, differentiation, and development—during the long lapse of historic and unhistoric centuries.

Now, the civilized man, standing in the midst of this vast moving aggregate, as its atomic unit and smallest factor, can lay but little claim to the careless freedom of the savage. He is hedged about by laws, and customs, and duties, and obligations, and swept along by the current of circumstances to a destiny which he has not altogether prepared for himself, and which he cannot altogether avoid.

There is another consequence of the law of evolution, in its application to social organisms, which is too important to be overlooked. A progression of complexities is also of necessity a progression of inequalities. And it is evident that, along with complexities and inequalities, in social, political, and ecclesiastical organization, we must have institutions of caste, with ordination and subordination of ranks and classes, in society, in the state, and in the church. Indeed, the radical, agrarian, red-republican theories of social, political, and religious equality, which seems to be taking possession of the world in these latter days, is in conflict with all the teachings of history, and with all the inductions and deductions of natural science and of speculative philosophy. They have not a single foot of ground to stand upon in all the universe which God has made. In this world, as

we have seen, we find the nearest approximation to the Utopian ideal of liberty and equality among the most savage and barbarous peoples; and the widest departure from it among those who have made greatest advancement in civilization. In the dark realms of that traitor angel, who drew after him the third part of Heaven's host down to perdition, it seems, from the glimpses afforded us in Holy Scripture, that there are greater and lesser fiends, and one who is chief of all. And in heaven itself, where the wicked cease from troubling, and the weary are at rest, and the redeemed are united to God in beatific vision, we read of angels and archangels; of dominions, and principalities, and powers; and that there is one glory of the sun, and another glory of the moon, and another glory of the stars; and that one star differeth from another star in glory.

The same law of increasing complexity with progressive differentiation of organs and functions in ascending evolution, holds good also in physics and in chemistry, and in all the kingdoms of inorganic nature, and even in the mechanical and architectural works of savage or of civilized men; but we have no time to pursue the argument here.

It remains now to make a summary statement of the scientific conclusions which we have obtained; and to study the general influence, for good or evil, which they have exerted on the times in which we live.

We have found that the relation between organic and inorganic nature is exceedingly intimate, with no abrupt line of demarkation stretching between them, but a gradual transition, which leaves no link wanting in the chain of things, from the lowest to the highest.

We have found that all the material constituents of organic creatures are derived from inorganic nature.

We have found that many of the forces of living organisms are derived from the forces of inorganic nature, either directly or by easily understood metamorphoses; and the inference is strong that all those whose origin has not been articulately traced are of similar nature; in a word, that all the imponderable forces of organic, as well as of inorganic, bodies are but Protean metamorphoses of motion.

We have found that the two great laws which lie at the foundation of all physical science, the law of the indestructibility of matter, and the law of the indestructibility of force, are of equal authority in the two great natural kingdoms, the organic and the inorganic.

We have found that the three mechanical laws of motion, bearing respectively the names of Galileo, Newton, and Kepler, are also equally applicable to the phenomena of organic and of inorganic bodies.

We have found that the method of creation pursued in the constitution of organic nature is not creation by the direct miraculous intervention of divine power, but creation by the divine operation of applied law, type rising out of type, as individual is known to rise out of individual.

We have found that both plants and animals begin their development from the same point, namely, the simple colloid cell, and proceed along widely diverging lines of evolution; plants, in their general plan of structure, being exothentic, and animals, endothentic.

We have found that both plants and animals develop in obedience to Von Baer's law of progressive differentiation

of organs and functions, by virtue of which they continually increase in complexity as they increase in power.

We have found that Von Baer's law is quite as applicable to sociological development as to biological development; so that social, political, and ecclesiastical evolution proceeds also by progressive differentiation of organs and functions, involving, as before, increase of complexity along with increase of power.

We have found that social phenomena are of essentially the same character as physical and biological phenomena, and regulated by essentially the same code of natural laws; so that sociology, including government, no longer aberrant and eccentric, becomes a recognized department of positive science.

These are among the latest and most notable of the general conclusions of modern science. I know very well that some of them will shock the religious sentiments and the religious beliefs of many of my hearers. Nevertheless, I have stated them plainly and fully, without hesitation and without fear. But I claim to be also a believer in the Christian religion, and in all the mysteries growing out of the doctrine of the incarnation; and I am able to sympathize with the fears of those who hold these things to be infinitely above all secular and human science. Still, if the scientific doctrines which I have expounded rest on a sufficient foundation of evidence, I do not see why we should refuse them recognition and credence. If they are true, they need no other warrant. If they are true, they can come in conflict with no other truth. Natural science and theology ought not to be enemies, but friends. God has not written one law in the

revolutions of the stars and the evolution of living organisms, and another law in the aspirations of human hearts and the intuitions of human minds—has not published one creed in the book of natural revelation, and another creed in the book of supernatural revelation. For my own part, I do not see that the hypothesis of organic evolution is antagonistic to any Christian dogma. I know that many good men imagine irreconcilable antagonism between the scientific theory and the Biblical revelation. But, then, I remember that, only a few centuries ago, the Biblical revelation was held to be inconsistent with the heliocentric theory of the solar system; and that, in our own generation, the demonstrations of geology as to the age of the earth were held to be inconsistent with the truth of Christianity. Now, the heliocentric astronomy and the geological chronology are both firmly established, and I do not know that the Christian revelation has lost authority in consequence. So with these new doctrines of the origin of species in the evolution of organic forms, and of the subjection of socialistic phenomena to scientific laws. The time will come when they will be questioned as little as the stellar revolutions or the long geological ages.

Nevertheless, I can understand the fear which the leaders of theological thought entertain on this subject. Practically, natural science and theology occupy antagonistic positions. For this, both of them have been, perhaps, equally to blame; for both have been arrogant and aggressive, and each has invaded the province of the other, as if there was not room enough in the world for both. Natural science is the study of the universe from the side of the

finite. Its doctrines are based on empirical observation. Its distinctive method is the Baconian induction. Theology, which in its large and general sense is synonymous with metaphysics and with ontology, is the study of the universe from the side of the infinite. Its *data* are the intuitions of the understanding. Its instruments are the processes of pure logic. They are, therefore, the counterpoles of universal philosophy, each being the complement of the other, and both being necessary to the comprehension of the ways of God toward man; God's providence being both natural and supernatural—*ὁ λόγος* becoming *ὁ ἀνθρώπος*—the infinite becoming the finite—constantly becoming, for with Him there is no past, no present, no future—always *eternal now*. The chronic disagreement between theologians and metaphysicians, and men of science, is of the same nature as the famous passage at arms between the two testy knights about the double shield which had one face of gold and one of silver. Each party recognizes the truth which it sees, but will not acknowledge the truth which it sees not. Each is right in what it affirms, and each is wrong in what it denies.

In the middle ages, the theological spirit was dominant all over Europe, and it is charged that in those ages science was unduly repressed. But if, in the middle ages, science was made to suffer unjustly, she has had her revenge; for certainly, in these modern times, and especially in this nineteenth century, of which we are all so proud, science has ruled the world with a rod of iron. "Commerce is king," said Carlyle, giving voice to the spirit of the age. He would have spoken quite as truly if he had said, "Science

is king," for even our modern commerce is the offspring of our modern science. Anyhow, we may safely say that material prosperity and secular science are the things upon which this age, of which we are denizens, specially prides itself—

> This age that blots life out with question-marks,
> This nineteenth century, with its knife and glass,
> That makes thought physical, and thrusts far off
> The heavens, so neighborly with man of old,
> To voids sparse-sown with alienated stars.

The times, indeed, are sadly out of joint. We have faith, not in God, but in man. We believe in railroads, and steam-engines, and the almighty dollar; and we look eagerly into the future, expecting the establishment of a political and social millennium, and the emancipation of humanity from all the ills that flesh is heir to—all to be wrought out by means of liberty and equality, private judgment, universal suffrage, the infallible wisdom of the mob, the progress of physical science, and the miraculous achievements of machinery. All this is very well, as far as it goes. But, alas! is it not written: "Man shall not live by bread alone, but by every word which proceedeth out of the mouth of God"? In saddest truth, the prevalent philosophy of doubt and unbelief, which has grown out of the wrong application of scientific methods, is not productive of organization and life, but is disorganizing and destructive; and its ultimate triumph would be to throw the world back into the anarchy and chaos out of which God's fiat called it in the beginning. The principles of this philosophy, indeed, are not new. They can be found implicitly contained in the very words

of the temptation which Satan addressed to mother Eve in the garden of Eden: "Eat, and ye shall not surely die; eat, and ye shall be as gods knowing good and evil." And it is worthy of remark that, in this Oriental *mythus* of the garden of Paradise and the temptation of Adam and Eve, the fruit of that forbidden tree which first brought death into the world, and all our woe, is not the fruit of any tree of evil name, in the common estimation of men—not the fruit of the tree of ignorance, not the fruit of the tree of superstition, not the fruit of the tree of kingly or of priestly oppression—none of all these dreadful things which our modern apostles of progress evoke so passionately whenever they would point a moral or adorn a tale—but the fruit of the tree of knowledge it is which is forbidden by the Most High! What a tremendous lesson, if we would only give it proper heed! This philosophy, then, which bases its hopes and promises upon the revelations of secular and earthly science, and which recognizes for man only an earthly and finite destiny, is not new. It made its appearance in the world along with the first man, and will probably leave it with the last. But in the providence of God, it has been reserved for quite recent centuries, and for the so-called Christian peoples of Europe and America, to make the principles of merely secular science the pillars of cloud by day, and the pillars of fire by night, to guide them through the wilderness of time and space, out of the bondage of Egypt into the liberty of the land of promise flowing with milk and honey.

My expressions are perhaps somewhat strong, and I would have them lead no one astray. Let it be borne in

mind, then, that while this secular and physical philosophy has been productive of much evil, it has also been productive of much good. And there is no inconsistency in this. Like every other philosophy, it is true and good in all its affirmations, and false and evil in all its negations. Whatever of positive doctrine, appertaining to its own proper domain, it has to offer us, we may accept without question. But it becomes false and misleading whenever it expressly denies, or tacitly ignores, or arrogantly relegates into the shadowy regions of the unknowable—that vast system of supernatural truth which lies beyond its cognizance. In its last analysis, the fallacy we are considering is but a special instance of the universal sophism, the sophism, namely, which results from taking the part for the whole, and drawing universal conclusions from particular premises. I cannot undertake the full discussion of this sophism; but a dogmatic statement of the leading metaphysical principles which such a discussion would involve may not be altogether useless. It is customary to speak of metaphysics as a shadowy, impalpable something, woven out of nonsensical fancies and transcendental moonshine. But I undertake to assert that it is the most real and the most certain of all the sciences, and the most indispensable of all. Without metaphysics we could have no physics. Without metaphysics, without ontology, we would have no solid foundation for any thing, whether in the domain of speculation or in the domain of fact; and in the crucible of critical analysis, all our arts and sciences would melt away like Prospero's cloud-capped towers and solemn temples, and, like the baseless fabric of a vision, leave not a wreck behind. Another very prevalent

opinion is, that the refinements of the higher philosophy are altogether beyond the understanding of the great mass of men. It may be so; but, for my part, I have learned to give the common people credit for a finer philosophical sagacity than is commonly attributed to them. A great deal of what passes current under the name of philosophy is incomprehensible, because it is false and dead, a mere form of words, full of sound, but signifying nothing. Only the true and the real can be known by any; and these can be known by all. The human intelligence is, in all human beings, substantially the same thing. The miraculous breath of God, by which man became a living soul, made all his tribes and generations into God's own image and likeness, and endowed them all, the least as well as the greatest, with the intuitive perception of all truth.

The ultimate principles of all knowledge are given in intuition. We *know* only what we *see*—what we see with the eyes of the body, or with the eyes of the mind, or with the eyes of the soul. Only principles, or ideas, in the Platonic sense, are primarily intelligible—intelligible *per se*. Facts in themselves have no value, and become intelligible only in the light of principles. All that *is* can be *known*. The *real* and the *knowable* are always identical. The unknowable and the unthinkable are also the unreal and the impossible—that which is not and which cannot be. Hence, whatever can be positively thought, must of necessity be true and real. Hence, also, all positive doctrines of all philosophical and religious systems, of all times and countries, are, in strictest use of language, *true* and *real;* not sophistical and uncertain, but of genuine authority and

value. Hence, also, all error and all evil are to be found in negations of the true and right, and not among things positive, having a local habitation and a name in the universe which God has. For God saw all that he had made, and behold it was very good. And hence, last of all, the consummate catholic philosophy is that which comprehends, in one homogeneous body of harmonious doctrine, all the fragmentary truths of all the fragmentary systems which have kept the world in conflict for so many centuries, each party fighting for the truth it clearly had, and living and dying for it, and each blindly refusing recognition and credence to the truth which it had not. The object of the intellect is *truth*. It can see, it can apprehend, it can comprehend nothing else. The object of the will is *good*. It can see, it can apprehend, it can comprehend nothing else.

Let no one imagine, from any thing I have said, that I undervalue our modern civilization; or the splendid achievements of our physical science. It is the peculiar merit of my philosophy that it undervalues nothing; while it is the peculiar defect of the prevalent philosophy that it undervalues every thing except secular science and material prosperity. Whatever is not amenable to ordinary scientific methods, whatever cannot be reached as the conclusion of a Baconian induction, is, for the majority of modern men, as if it had no existence at all. Now, the Baconian induction, the great instrument of scientific research, can never conduct to a belief in God, free-will, and immortality. If its weakness was properly recognized, and its inapplicability to such questions frankly conceded, no harm would be done.

But the men of science will not admit the possibility of any certitude which lies outside of the methods and conclusions of science. For them, what cannot be reached by scientific methods cannot be reached at all, and is, therefore, quietly ignored. I am confident that it will be conceded that, in my discussion of scientific questions in the body of my address, I have done full justice to natural science and its methods. Indeed, many will believe that I have gone too far and admitted too much. I think I may claim, also, that the metaphysical philosophy which I have advocated before you, is not inimical to science, but recognizes all her legitimate rights and privileges. But my philosophy teaches us that there is something more than mere physical science; that the marvelous universe which God has made is not altogether so simple an affair as many seem to think; that there are more things in heaven and earth than are dreamt of in our books of science. The philosophy which I advocate goes still farther. It furnishes the means for the reconciliation of all our conflicting creeds, whether social, political, moral, or religious; and is thus already a prophecy of that golden age of which the poets sing; of that thousand years of peace to which so many weary souls look forward with eager yearning, crying, How long, O Lord, how long?

But I know that your patience is exhausted even as my strength is; and as, in the course of my argument, I have made many abrupt transitions, so now I approach an abrupt close. I know that I have uttered many things that will seem strange to many, and some things that will not be easily understood by some. But I have felt that these

things ought to be said, and I have said them. If only a few of the many who have heard me so patiently shall be led by any thing I have said to take juster views of the respective claims of natural science and of metaphysical philosophy, to recognize the sophistical character of the antagonism which has existed so long between religion and science, and to have a better understanding of the hierarchical organization of living things, especially of those complex social organisms, states and churches, I shall go back to my sunny Southern home, in the beautiful city by the side of the Mexican Gulf, among the magnolia groves and the orange blossoms, and all the perfumes of the sweet South, feeling that I have had my exceeding great reward.

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